Embryonic and Larval Development in the New Zealand Rock Oyster, *Crassostrea glomerata* (Gould)

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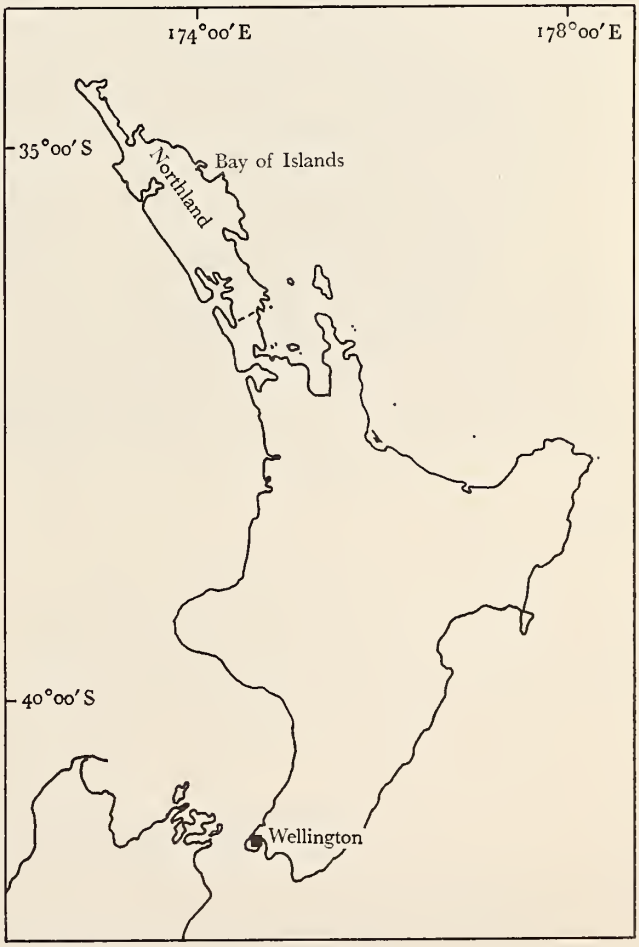
(3 Plates; 2 Text figures; 1 Map)

INTRODUCTION

The biology of *Crassostrea glomerata* (Gould, 1850), the New Zealand rock oyster, is almost unknown, though the oyster has been cultivated in the northern parts of the country since 1964. Studies on the oyster, particularly on its reproduction and larval development, were begun in 1969, and some of the results of the study on development are described in this paper. The study adds to the data on the embryonic development of oviparous oysters, on which published information is sparse: the relevant studies are by Brooks (1880) and Galtsoff (1964) on *Crassostrea virginica* (Gmelin, 1791), by Fujita (1929) on *C. gigas* (Thunberg, 1793), by Amemiya (1926) and Le Dantec (1968) on *C. angulata* (Lamarck, 1819), and by Roughley (1933) on *C. commercialis* (Iredale & Roughley, 1933).

MATERIALS AND METHODS

Cleavage and development up to the early veliger stage was observed in a group of oysters which had spawned spontaneously in the laboratory and also in another group which was induced to spawn. Both groups of oysters had been collected at the same time from intertidal beds in the Bay of Islands (see Map) during the 1970 - 1971 breeding season and held for about 2 weeks in tanks in the laboratory in Wellington at 17° ± 1° C. Spawning occurred on 1 December 1970 in a group of oysters which had just been removed to a container of renewed sea water (temperature 18°C), and these embryos developed to the trochophore stage and then died. On 3 December 1970 a fresh group of oysters was placed in a pail of renewed sea water and the temperature of the water raised to 21° C. The oysters spawned within 90 minutes, and were afterwards removed from the pail. After about 2 hours, when cleavage had begun, the water, with the embryos, was



Map of North Island of New Zealand, showing locations of places mentioned in the text

poured into shallow plastic trays or into 500-ml beakers through a fine nylon mesh (135 μm), which retained the debris. All stages of development up to the straight-hinged veliger were followed in this culture. Heavy mortalities on the third day nearly wiped out the whole stock of larvae, but some reared in sterile sea water survived until the ninth day after fertilization. Attempts to feed the larvae, begun on the third day, failed, since unialgal food such as *Isochrysis*, *Monochrysis*, and *Dicrateria* was not then readily available.

Plankton hauls for free-swimming larvae were made in the Bay of Islands from the second week of December 1970 onward, and sampling was repeated during the 1971-1972 season in many bays in Northland. Sampling lasted until the end of March in both years. All stages of larvae, from 85 to 320 μm in length, were recorded in the plankton during summer. The specific identification of planktonic larvae was confirmed by rearing late stages of larvae to settlement and also by examining recently settled pediveligers on spat collectors set in different parts of the bay.

Except for larvae of *Crassostrea commercialis*, for which data have been taken from ROUGHLEY (1933), dimensions of all other species of larvae have been verified by direct observation.

OBSERVATIONS

The times mentioned in the following description on early development refer to the time from fertilization.

The fertilized egg (Figure *1*), measuring about 40 μm, forms the first polar body within 30 min of the appearance of the fertilization membrane (Figure *2*), followed within 45 - 60 min by the second polar body. The division of the egg (Figures *3* to *6*) follows the usual pattern for molluscan eggs and results in the gastrula, 5 to 7 hrs after fertilization (Figure *7*).

The earliest free-swimming trochophores (Figure *8*) emerge within 12 to 18 hrs, and the trochophore stage persists for almost another 24 hrs. The larval shell develops after 36 - 42 hrs, and the first veligers, measuring 50 - 60 μm and 45 - 50 μm in height, appear. The characteristic feature of the early veliger of *Crassostrea glomerata* is its saddle-shaped dorsal margin with a shallow depression (Figure *9*). The larval shell is slightly asymmetrical with the anterior border more uniformly rounded than the posterior. D-stage veligers grew to a size of 70 × 68 μm by the fourth day, and though several larvae of this batch lived up to the ninth day, no further growth took place under laboratory conditions, primarily because of lack of suitable food.

Further development was followed in planktonic stages of the larvae collected in the field. The earliest planktonic stage larvae taken in samples were 80 to 90 μm long and were nearly the same height (Figure *10*).

The larval outline is nearly circular and well defined at this stage, with the valves nearly equal. The subsequent growth of the valves is unequal; at a larval length of about 110 μm the asymmetry is apparent and the umbones are nearly rounded. During further growth, the right umbo enlarges and begins to extend beyond the dorsal margin of the right valve. At the same time larval dimensions also change, and height begins to exceed length (Text figure 18) : shell height begins to exceed the length from the time the larva is 120 μm long, and in later stages, from a length of 270 μm, this increase is very pronounced. When the larva is nearly 270 μm long and 290 μm tall (Figure *11*) a pigment spot develops and the larva soon enters the pediveliger stage. In the laboratory the pediveliger alternately swims by means of the velum or uses its foot to crawl along the bottom. The fully developed pediveliger (Figure *12*), usually 320 × 350 μm in size, spends more time crawling as it nears metamorphosis. From a length of 270 μm the umbones become more prominent as the larva approaches the pediveliger stage, with the right umbo rising prominently over the margin of the right valve (Figure *14*).

Attachment takes place when the larva is 320 to 330 μm long and 350 to 360 μm tall. The late-stage larva is usually a pale pinkish purple, which contrasts with the yellowish brown centre formed by the digestive diverticula. Fully developed larvae are darker, especially around the umbones. Nearly black larvae, 320 × 360 μm, are seen late in the breeding season.

Eyed larvae, 290 to 300 μm long, picked from plankton hauls and introduced into finger bowls in the laboratory,

Explanation of Figures *9* to *14*

Figure *9*: Straight-hinged veliger, 70 × 65 μm, fourth day

Figure *10*: A group of 6 larvae, showing stages of growth from a length of 90 μm to 180 μm; larvae are 90 × 90, 110 × 110, 150 × 155, and 180 × 190 μm

Figure *11*: Larva 270 × 290 μm; pigment spot formed

Figure *12*: Fully developed stage 320 × 360 μm just before settlement

Figure *13*: Lateral view of a pediveliger to show the prominent right umbo

Figure *14*: Apical region of spat, 3 days old, showing the prodissoconch

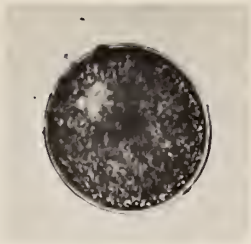


Figure 1

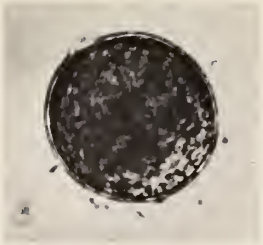


Figure 2

Figure 3

Figure 4

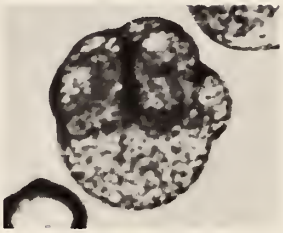
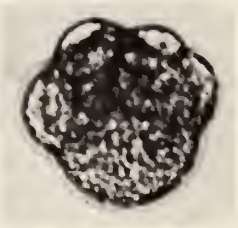


Figure 5



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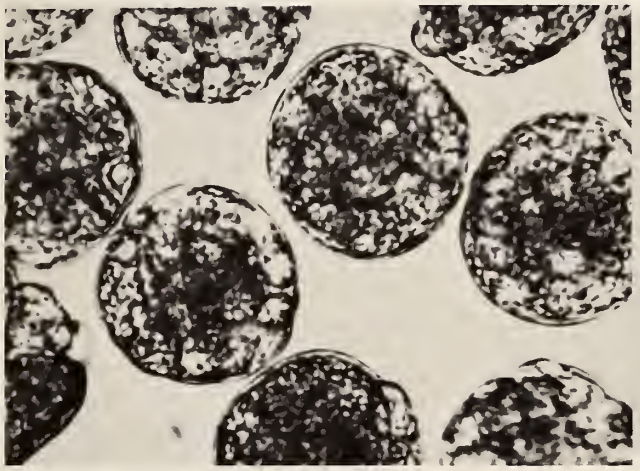

Figure 7

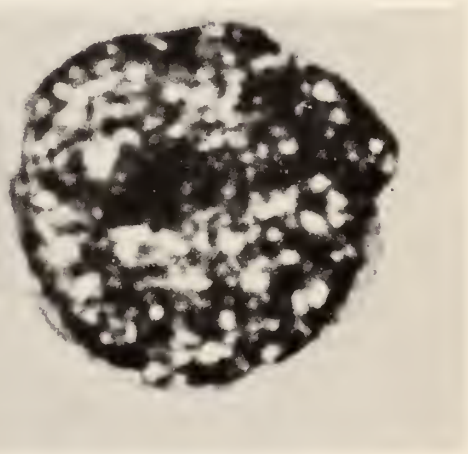

Figure 8

Figure 1: Fertilized egg, 40 μm
Figure 2: Formation of first polar body
Figure 3: First division, 2 blastomeres
Figure 4: Second division, 4 blastomeres, D-sector largest
Figure 5: Third division, 4 micromeres cut off apically
Figure 6: Fourth division, ring of 8 micromeres
Figure 7: Stages leading to gastrula
Figure 8: Ciliated trochophore, 45 μm, 15 hr after fertilization

Figure 9

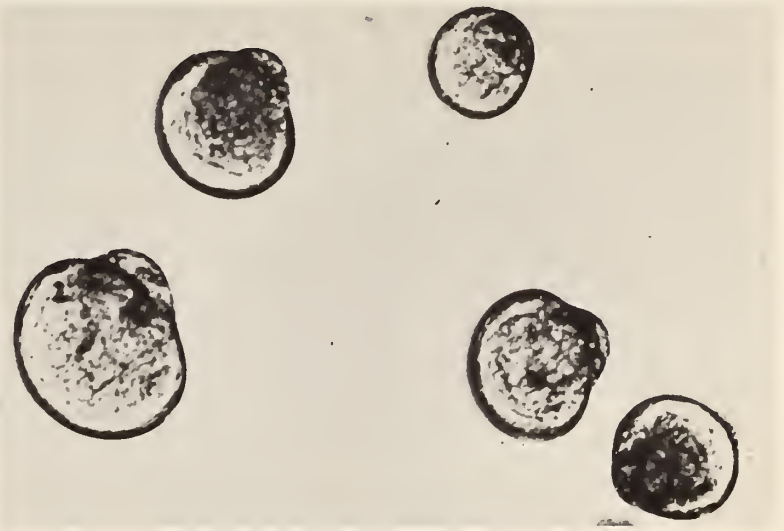

Figure 10

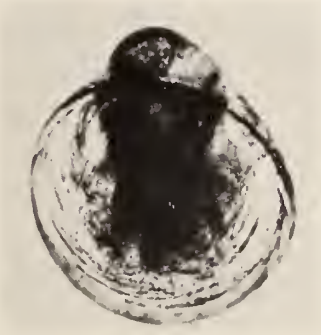

Figure 11

Figure 13

Figure 12

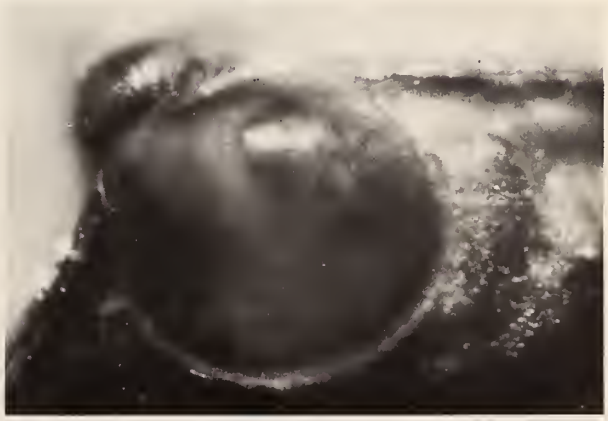

Figure 14